

## CLAIMS

1. Motion control apparatus for use with a rod, with the rod having an axis defining an axial direction, with the rod shiftable in the axial direction, with the apparatus comprising, in combination:

a housing having an inside housing surface forming a hole to receive the rod there through along the axial direction;

a piston mounted in the inside housing surface of the housing that is moveable between a rod motion controller engaged position and a rod motion controller unengaged position;

an end cap slideably mounted on the inside housing surface of the housing to allow motion of the end cap in the axial direction;

a friction collar mounted between the housing and the end cap, with an engaging force being generated by the friction collar with the rod when the piston is moved to the rod motion controller engaged position, and when the piston is in the rod motion controller unengaged position, the rod moves in the axial direction; and

a backlash reducer reducing relative motion in the axial direction between the friction collar and the housing and between the friction collar and the end cap when the piston is in the rod motion controller engaged position and when the piston is in the rod motion controller unengaged position to reduce backlash in the axial direction when the piston is in the rod motion controller engaged position.

2. The apparatus of claim 1 with the backlash reducer comprising a holder mounted on the inside housing surface in an adjustable position in the axial direction and abutable with the end cap to reduce backlash by reducing relative motion in the axial direction between the friction collar and the housing and between the friction collar and the end cap.

3. The apparatus of claim 2 with the holder comprising:

an internal retaining ring mounted on the inside surface of the housing, with the end cap having a first end in contact with the friction collar and a second end held by the internal retaining ring in a backlash reducing position to reduce backlash by reducing relative motion in the axial direction between the friction collar and the housing and between the friction collar and the end cap.

4. The apparatus of claim 2 with the holder comprising, in combination:

an internal retaining ring mounted on the inside surface of the housing; and

a backlash reducing shim, with the end cap having a first end in contact with the friction collar and a second end in contact with the backlash reducing shim, and with the backlash reducing shim positioned intermediate the internal retaining ring and the end cap to reduce backlash by reducing relative motion in the axial direction between the friction collar and the housing and between the friction collar and the end cap.

5. The apparatus of claim 4 with the friction collar having a plurality of tracks to support a plurality of balls, with the balls positioned between the plurality of tracks and the piston, and with the friction collar having a plurality of slits in a first direction and a plurality of slits in a second direction, with the first direction opposing the second direction, with the plurality of slits in the first direction and the plurality of slits in the second direction providing ease of deflection of the friction collar, and with the piston positioned to press the balls into the tracks to cause the engaging force to be generated by the friction collar.

6. The apparatus of claim 2 with the holder comprising a threaded cap having an outside thread, with the inside surface of the housing having an inside thread, with the outside thread mating with the inside thread to reduce backlash by reducing relative motion in the axial direction between the friction collar and the housing and between the friction collar and the end cap.

7. The apparatus of claim 6 with the friction collar having a plurality of tracks to support a plurality of balls, with the balls positioned between the plurality of tracks and the piston, and with the friction collar having a plurality of slits in a first direction and a plurality of slits in a second direction, with the first direction opposing the second direction, with the plurality of slits in the first direction and the plurality of slits in the second direction providing ease of deflection of the friction collar, and with the piston positioned to press the balls into the tracks to cause the engaging force to be generated by the friction collar.

8. The apparatus of claim 2 with the friction collar having a plurality of tracks to support a plurality of balls, with the balls positioned between the plurality of tracks and the piston, and with the friction collar having a plurality of slits in a first direction and a plurality of slits in a second direction, with the first direction opposing the second direction, with the plurality of slits in the first direction and the plurality of slits in the second direction providing ease of deflection of the friction

collar, and with the piston positioned to press the balls into the tracks to cause the engaging force to be generated by the friction collar.

9. The apparatus of claim 1 with the backlash reducer comprising integrally formed members that cooperate to restrain relative motion between the friction collar and the housing and between the friction collar and the end cap.

10. The apparatus of claim 9 with integrally formed members comprising, in combination:

an outside thread on the end cap; and

an inside thread on the inside surface of the housing, with the outside thread mating with the inside thread to reduce backlash by reducing relative motion in the axial direction between the friction collar and the housing and between the friction collar and the end cap.

11. The apparatus of claim 10 with the friction collar having a plurality of tracks to support a plurality of balls, with the balls positioned between the plurality of tracks and the piston, and with the friction collar having a plurality of slits in a first direction and a plurality of slits in a second direction, with the first direction opposing the second direction, with the plurality of slits in the first direction and the plurality of slits in the second direction providing ease of deflection of the friction collar, and with the piston positioned to press the balls into the tracks to cause the engaging force to be generated by the friction collar.

12. The apparatus of claim 1 with the friction collar having a plurality of tracks to support a plurality of balls, with the balls positioned between the plurality of tracks and the piston, and with the friction collar having a plurality of slits in a first direction and a plurality of slits in a second direction, with the first direction opposing the second direction, with the plurality of slits in the first direction and the plurality of slits in the second direction providing ease of deflection of the friction collar, and with the piston positioned to press the balls into the tracks to cause the engaging force to be generated by the friction collar.

13. The apparatus of claim 12 with the piston having a surface in contact with the plurality of balls and with the surface having the shape of a cone to progressively engage the plurality of balls.

14. The apparatus of claim 12 with the piston having a flange and a plurality of seals to create a sealed fluid chamber with the housing, for the

containment of a fluid, on one side of the flange, with the sealed fluid chamber having a first fluid port in the housing.

15. The apparatus of claim 14 with the flange having a second side and the housing having a second fluid port for the exhaust of fluid as the rod moves to the rod motion controller engaged position and the intake of fluid as the piston moves to the rod motion controller engaged position.

16. The apparatus of claim 15 with the piston actuated by a spring, with the spring positioned on the second side of the flange between the housing and the flange of the piston.

17. Method comprising:

providing a housing with an internal passage large enough to accommodate a rod there through;

mounting a friction collar into the housing with the friction collar positioned to selectively hold the rod when the rod is inserted in the internal passage;

mounting an end cap into the housing after the mounting of the friction collar;

applying a force to the end cap after mounting into the housing, with the end cap, the friction collar and the housing being in a relative position to eliminate any space between the end cap and the friction collar and between the friction collar and the housing; and

holding the relative position of the end cap, the friction collar and the housing to reduce backlash in operation.

18. The method of claim 17 with holding the relative position of the end cap, the friction collar and the housing comprising:

manufacturing an inside thread in the internal passage of the housing;

manufacturing an outside thread on the end cap; and

screwing the end cap by the outside thread into the inside thread to hold the relative position of the end cap, the friction collar and the housing.

19. The method of claim 17 with holding the relative position of the end cap, the friction collar and the housing comprising:

installing a holder in the internal passage to abut with the end cap and to hold the end cap, the friction collar and the housing in the relative position.

20. The method of claim 19 with installing the holder comprising:

installing an internal retaining ring in the internal passage of the housing;  
measuring a backlash space from the end cap to the position of the internal retaining ring after applying the force to the end cap to eliminate any space between the end cap and the friction collar and between the friction collar and the housing;  
and

installing a backlash reducing shim intermediate the internal retaining ring and the end cap, with the backlash reducing shim having a width that is equal to or less than the backlash space so that the backlash reducing shim takes up the backlash space between the internal retaining ring and the end cap to hold the relative position of the end cap, the friction collar, and the housing.

21. The method of claim 19 with installing the holder comprising:  
manufacturing an inside thread in the internal passage of the housing;  
manufacturing an outside thread on a threaded cap; and  
screwing the threaded cap by the outside thread into the inside thread to hold the relative position of the end cap, the friction collar and the housing.